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Insecticides; Their Preparation and Use.

ENTOMOLOGICAL SERIES, NO. 2.

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Notice as to Bulletins.

The Bulletins of this Station are mailed free to citizens of Connecticut who apply for them, and to others as far as the limited editions permit.

Applications should be renewed annually before January 1st.

The matter of all the Bulletins of this Station, in so far as it is new or of permanent value, will be made part of the Annual Report of the Station Staff.

All Bulletins earlier than No. 71 and Nos. 83, 86, 93, 101, 102 and 118 are exhausted and cannot be supplied.

Notice as to Supply of Station Reports.

The Station has no supply of its Annual Reports for the years 1877, 1878, 1879, 1880, 1881, 1882, 1883, 1887 and 1891.

The Annual Report of this Station, printed at State expense, is by law limited to an edition of 7,000 copies.

After exchanging with other Experiment Stations and Agricultural Journals, the Reports remaining at the disposal of the Station will be sent to citizens of Connecticut who shall seasonably apply for them, and to others as long as the supply lasts.

Former Reports Wanted.

There is frequent call for our earlier Annual Reports on the part of public Libraries, students, chemists, naturalists, and station workers.

Persons who can supply copies of Reports of this Station for any of the years above named, will be likely to find purchasers by communicating with the Director.

INSECTICIDES: THEIR PREPARATION AND USE.

By W. E. Britton.

Bulletin 125 gives advice upon the methods of spraying plants to prevent diseases caused by fungi. The present Bulletin describes the materials used to protect plants from the attacks of insects, and the methods of preparing and applying these materials. Some of them have been mentioned in Bulletin 121, and in each of our Annual Reports since 1893 may be found brief notes regarding injurious insects and proposed remedial treatment.

Spraying pumps, suitable for applying insecticides as well as fungicides, are fully described in Bulletin 125 and the reader is referred to its pages for information regarding them. A special pump attachment for applying kerosene, not mentioned in Bulletin 125, is described on page 7 of the present bulletin.

The insects which are most commonly injurious to plants may be roughly divided into two classes; those which eat and thus destroy the vegetable tissues, and those which destroy these tissues by inserting their beaks and sucking out the plant juices.

To the former class belong canker worms, elm-leaf beetles, the larvæ of the codling moth, cut worms, potato beetles and tent caterpillars. To the latter class belong the squash bugs, plant lice and scale insects.

Insects of the former class are usually destroyed by spraying the leaves of the plants to be protected, with some poison, usually a preparation of arsenic, which the insects will unavoidably eat, with the foliage.

Insects of the other class, namely, those which suck out the plant juices, are destroyed by contact poisons or irritants, by fumes, or suffocation. The arsenical poisons, which coat the leaf surfaces, but cannot enter the plant juices, have no effect whatever on sucking insects.

Therefore, the method to be used in fighting insect pests is determined, first, by the kind of insect to be destroyed, and then by the apparatus at hand and the convenience of the operator.

Insects are usually destroyed by one of three* distinct methods or treatments, viz :

(1) *By internal poisoning*—where the insect devours portions of plants that have been coated with hellebore, Paris green, or any of the arsenical poisons.

(2) *By contact poisons or irritants*—substances which come in direct external contact with the insect and which kill by their irritating or corrosive action. Whale-oil soap, kerosene, either pure or emulsified, tobacco decoction and hellebore are examples.

(3) *By poisonous fumes and by suffocation*—where the insect is poisoned or suffocated through the breathing pores by a poisonous gas, or by a fine powder. Tobacco fumes, hydrocyanic acid gas, carbon bisulphide, benzine and fine dust of any kind belong to this class of insecticides.

MATERIALS USED AS INSECTICIDES.

Arsenical Poisons.

Paris Green, aceto-arsenite of copper, contains arsenious acid, copper and acetic acid. It is a rather coarse powder, bright green in color, and when mixed with water needs constant stirring, to keep it in suspension. If not well stirred while spraying, the poison will settle to the bottom of the tank and, because of its concentration, will injure the foliage, while the liquid above it is of almost no value for destroying insects. Even when well mixed with water an application of Paris green is likely to injure tender foliage. This injury may, however, be prevented by adding lime, as in the following formula :

FORMULA FOR SPRAYING MIXTURE OF PARIS GREEN.

Paris green	1 pound.
Fresh stone lime	3 pounds.
Water	100 to 200 gallons.

The lime should be fresh and slaked just before mixing.

*Insects are sometimes kept away by the use of substances known to be obnoxious or distasteful to them—as camphor is used to keep off the clothes moth. Trapping, jarring trees and other mechanical methods are also occasionally used to destroy insects.

When Bordeaux Mixture* is to be applied to orchards Paris green should be added to it in the proportion of ½ lb. to each 45 or 50 gallons, thus making a combined insecticide and fungicide.

The price of Paris green is subject to variation, but usually it retails for about twenty cents per pound.

London Purple.—This is a waste product obtained in the manufacture of aniline dyes. Nearly half its weight may consist of arsenious acid, though the percentage varies considerably. In some samples much of the arsenic is in a soluble form, which is very likely to injure foliage, unless lime is added to the mixture. This poison remains in suspension somewhat longer than Paris green. It may be mixed with water and lime, by the formula already given for Paris green. It costs from six to fifteen cents per pound.

Arsenate of Lead.—A white powder, quite insoluble in water, and for this reason less likely to injure foliage than the other arsenical poisons, even when used in excessive quantity.

FORMULA FOR SPRAYING MIXTURE OF ARSENATE OF LEAD.

Acetate of lead	11 ounces.
Arsenate of soda	4 "
Water	100 to 200 gallons.

Dissolve the acetate of lead and the arsenate of soda, *each by itself*, in a gallon or two of warm water, and pour them with constant stirring into the rest of the water. Arsenate of lead forms and is precipitated as a fine white powder, which settles less quickly than Paris green.

* Bordeaux Mixture is prepared as follows:

Sulphate of Copper,	5 lbs.
Lime,	5 lbs.
Water	45 to 50 galls.

Dissolve 5 lbs. of sulphate of copper either by adding it to two or three gallons of hot water or by enclosing it in a coarse bag and suspending the whole in a half-barrel of cold water so that the water just covers the sulphate. When dissolved, dilute with cold water to 15 gallons. Slake 5 lbs. of perfectly fresh (not air-slaked) stone lime in a little water, preferably hot. When thoroughly slaked, dilute and pour it into the spraying-cask, using, if necessary, a strainer or piece of coarse bagging to strain out the coarse sediment. If the lime is of good quality and is properly slaked, there will be no lumps. Add water to make 30 galls. Pour the sulphate solution *as rapidly as possible* into the white-wash, stirring thoroughly for two or three minutes. The resulting mixture should be of a pure, deep blue color, and should settle very slowly.

If, for any reason, it is more convenient to reverse the process and pour the white-wash into the sulphate solution, this may be done with equally good results, *providing both solutions are dilute.*

Hellebore.

This insecticide is made by grinding the dried roots of the white hellebore. It is applied as a powder or mixed with water. Hellebore is an internal poison like the arsenites, and also appears to poison some larvæ, especially the currant-worm, by contact. Against the larvæ of saw-flies like the rose and cherry slugs and the currant-worm, hellebore is very efficacious. It is less poisonous to man than preparations of arsenic, and therefore is to be preferred for use in the garden or near the house. It is however distinctly a poison, and when it is applied dry, great care should be used to avoid inhaling the powder. It loses strength when exposed to the air, and a fresh supply should be procured each season. Use one ounce to two gallons of water.

Contact Poisons.

Whale-oil soap.—Crude fish-oil and not whale-oil is used in manufacturing this article. It is not uniform in composition, which accounts for the variable results obtained by experimenters. Two soaps now upon the market, considered by Prof. Smith* to be fairly uniform in composition, are—"Anchor Brand" made by Leggett & Bro., 301 Pearl st., New York, and the Good soap made by James Good, 514–518 Hurst st., Philadelphia. The "Anchor Brand" soap sells for ten cents per pound, or fifteen dollars per barrel of about four hundred pounds. The Good soap costs about four cents per pound in bulk. Strong solutions of whale-oil soap sometimes thicken or solidify so that they cannot be applied in the form of a spray. This is most apt to happen if soda instead of potash is used in making the soap. Such solutions, however, liquify when gently heated.

Formula for Whale-oil Soap Solution.

For plant-lice and other sucking insects, on a plant in foliage use: one pound of soap dissolved in five gallons of water. For San José and other scale-insects on dormant trees apply: two pounds of soap in one gallon of water.

Kerosene.—This has been used recently to kill the San José scale. In New Jersey the results have been successful, while in some other States great injury has followed its use, the fruit trees being killed or seriously injured. Kerosene should be applied in the form of a *very fine spray* at a time when the tree is *perfectly dry* and when the application will evaporate quickly. It should not be used on a damp or cloudy day.

* New Jersey Experiment Station, Bull. 125.

Kerosene and Water.—Kerosene and water can be mixed under pressure, and a pump attachment is now manufactured expressly for this purpose. The accompanying figures show pail and barrel pumps with kerosene attachment, which is said to deliver kero-

Fig. 1.

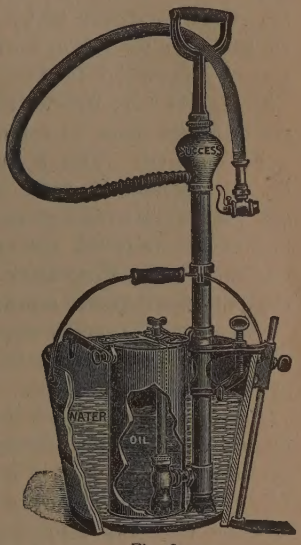

Fig. 2.

sene with water in almost any proportion desired.* A mixture of kerosene and water is much less injurious to foliage than the clear article, and kills many insects quite as readily.

Kerosene Emulsion.—This has long been the standard preparation for destroying sucking insects, and the labor involved in its preparation is perhaps its greatest disadvantage. It should be made as follows:

* This attachment is made by the Deming Co., Salem, Ohio, and is also fitted to their knapsack sprayer. In each case it can readily be removed. It is stated to have given satisfaction at the Cornell University station. The manufacturer's list prices for pumps with this attachment are as follows:—

Pail pump	$10.00
Knapsack pump	18.00
Barrel pump, with iron air-chamber	26.00
Barrel pump, with brass air-chamber	30.00

FORMULA FOR KEROSENE EMULSION.

Kerosene	2 gallons.
Common or whale-oil soap	½ pound.
Water	1 gallon.

Dissolve the soap in the heated water and while boiling hot remove from the fire and add the kerosene. This mixture while hot should be driven with a spraying pump through a coarse nozzle back into the tub or barrel which holds it until the whole is a creamy mass which thickens and becomes jelly-like upon cooling. This may be kept indefinitely, and should be diluted for use with ten or fifteen times its volume of water.

Fir-Tree Oil.—This is said to contain the essential oil of the fir. It is soluble in water and may be used in the proportion of one pint of oil to five to ten gallons of water. It is chiefly used in greenhouses to kill the mealy-bug, and it destroys all sucking insects as well. Cost alone precludes its more general use. It retails for seventy-five cents per pint.

Tobacco.—Tobacco is one of our best contact poisons, and may be prepared by steeping one pound of tobacco or tobacco stems in two gallons of water.

Pyrethrum or Persian Insect Powder.—This powder is made by grinding the flower heads and stems of plants belonging to the genus *Pyrethrum*. It is injurious to the lower forms of animal life but harmless to man or the higher animals. It can be used in water (one ounce to three gallons) or dusted on the plants. Used in the former way, it kills by contact, and in the latter way by suffocation as well. It is also moistened and burned for the purpose of killing mosquitos, flies, and cock-roaches, in dwellings.

Poisonous and Suffocating Fumes.

Tobacco Fumes.—Where plants are confined, as in a greenhouse or under a cloth tent, the fumes from slowly burning, damp, tobacco stems kill sucking insects. Too dense a smoke often injures tender plants.

Hydrocyanic Gas.—To generate this gas, pour three fluid ounces of water into a shallow earthenware vessel, add one fluid ounce of commercial sulphuric acid and finally one ounce of fused potassium cyanide. This makes enough gas to fill a space of one hundred and fifty cubic feet.

This treatment has been used extensively in California against San José scale, and also in eastern nurseries. A tight building

in which nursery stock can be placed, or an oiled canvas tent to envelop the tree is necessary. Trees should be treated for one hour.

Extreme caution must be taken in the use of this treatment, as the gas is an exceedingly dangerous poison.

Carbon Bisulphide is used to destroy insects in stored grain. One pound of the liquid placed in shallow dishes inside a closed bin is enough to kill the insects in one hundred bushels of grain if left for twenty-four hours. *This substance is very inflammable and no form of fire should be brought near it.* Its vapor is also poisonous to animals.

Dust.

Many delicate larvæ like rose slugs and cherry slugs, may be destroyed by blowing upon them any very fine dust or powder which has no poisonous properties whatever, like soot, ashes or fine dust from the road. This fine material stops up the breathing pores of the insect and kills it by suffocation. Finely ground tobacco, hellebore, or pyrethrum are often used in this way, and as these substances are poisons as well, they are more sure to kill the insects against which they are used. For dusting plants several forms of powder guns have been devised and put on the

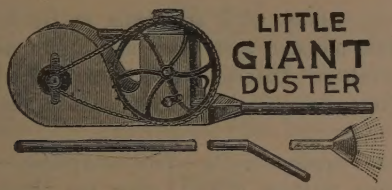

Fig. 3.

market. Fig. 3 shows a form which is manufactured by Leggett & Bro., 301 Pearl street, New York, and sells for $3.50.

These dusters can be used for applying arsenites or contact poisons where these are used in powder form.

WHEN TO APPLY INSECTICIDES.

Plant lice and scale-insects may infest almost all kinds of plants. All the species do the same kind of injuries, and with a few exceptions all may be destroyed in the same manner. For the

sake of brevity such insects are mentioned here collectively instead of separately under each host-plant in the following list.

Plant-lice.—Plant-lice are found on tender shoots and leaves of plants, which they damage or destroy by sucking the juices. On fruit trees they usually infest the under surface of the leaves. They may be destroyed by spraying with whale-oil soap solution, kerosene and water, kerosene emulsion, or tobacco decoction applied whenever the insects are found.

Scale-insects.—These fasten themselves on the bark of the trunk and branches and sometimes upon the leaves and fruit. Infested trees should be sprayed with whale-oil soap solution or kerosene and water. The San José scale can best be destroyed in winter, when the trees are dormant. In winter clear kerosene may be used against this scale, but whale-oil soap is a safer though probably less effective treatment.

List of Plants and the Insects that most Commonly Attack Them.*

Apple.

Bud-moth.—Spray with arsenicals (i. e. Paris green, London purple or arsenate of lead) in Bordeaux mixture just before blossoms appear.

Canker-worm.—Spray with arsenicals in Bordeaux mixture, once just before blossom buds open, and again as soon as the blossoms have fallen. Caterpillars begin to feed while leaves are expanding. Repeat applications at intervals of one week as long as necessary.

Codling-moth—Apple-curculio—Tent-caterpillar.—Apply arsenicals in Bordeaux mixture directly after the blossoms fall, and repeat at intervals of ten days or two weeks. Keep the fruit and foliage well coated for two months.

Asparagus.

Asparagus-Beetle.—Spray or dust plants with hellebore when the cutting for market is finished for the year. Spraying with Paris green has been used with success against this beetle.

* Only those insects which can be held in check by the proper use of insecticides are mentioned in this list. Mechanical devices, and the insects combatted by such means, are not included.

Cabbage.

Imported Cabbage butterfly or Cabbage worm — Cabbage Plusia.—Spray or dust young plants with hellebore or some form of arsenic. *When heads are forming use pyrethrum instead,* either dry or mixed with water.

Carrot, Celery and Parsley.

Celery Caterpillar.—Dust with hellebore or pyrethrum. The arsenicals are effective, but there is danger attending their use upon the parts of plants which are intended for food.

Cherry.

Slug.—Spray with arsenicals in Bordeaux mixture, or a solution of whale-oil soap.

Curculio.—See under plum.

Cucumber.

Striped Beetle.—Spray or dust with arsenicals whenever the beetle appears.

Currant and Gooseberry.

Imported Currant-worm.—Spray with hellebore as soon as leaves unfold, or dust it on the plants whenever the larvæ appear.*

Grape.

Grape-slug or Sawfly.—This insect is easily destroyed by the use of the arsenicals, hellebore, or the contact poisons.

Flea-Beetle.—Spray with arsenicals when the buds are first attacked by the adults, and again when larvæ appear.

Peach.

Curculio.—See under plum.

Pear.

Codling-Moth.—See under apple.

Slug.—Use arsenicals in Bordeaux mixture, same as for the cherry slug.

Psylla.—Spray thoroughly with kerosene emulsion when the leaves are first expanding. The insects are then young, and not enveloped in honey-dew. If later applications are necessary they should be made just after a rain.

* Dry hellebore is poisonous when inhaled and the operator should handle it with care.

Plum.

Curculio.—Arsenicals in Bordeaux mixture should be applied once before blossoms open, and again just after they have fallen.*

Canker-worm.—See under apple.

Potato.

Colorado Beetle.—Spray with arsenicals in Bordeaux mixture when the beetles first appear and repeat as often as necessary. The arsenicals may also be dusted upon the plants.

Rose.

Slug.—Dust with any fine powder, or spray with hellebore or the arsenicals.

Leaf-hopper.—Spray the under surface of the leaves with whale-oil soap solution or kerosene emulsion. When plants are wet dust freely with pyrethrum or ground tobacco.

Squash and Pumpkin.

Striped Beetle.—See cucumber.

Squash Bug.—Spray the young bugs with kerosene emulsion: dust with pyrethrum.

SIX RULES TO BE OBSERVED IN SPRAYING.

1. Never spray fruit trees when in bloom, for bees are killed thereby. Bees are needed to pollinate the blossoms.

2. Always begin the treatment early. If the foliage has been destroyed there is little use in spraying the tree.

3. Use care in handling the poisons. Do not store them where children or animals can get at them.

4. When possible spray when there is promise of fair weather. Never spray when a storm is beginning.

5. Perform the work thoroughly. Be sure and cover every portion of the plant with the liquid.

6. It is advantageous to apply Paris green and Bordeaux mixture together when admissible. Injuries resulting from the attacks of both insects and fungi will thus be forestalled.

* Many persons fight this pest entirely by jarring the trees each morning and destroying the beetles which are collected.